Chapter 12

Craniomandibular Disorders and the Choice of Mandibular Reference Position in Orthodontic Treatment

Farid Bourzgui, Hakima Aghoutan and Samir Diouny

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/60061

1. Introduction

Craniomandibular disorders (CMDs) and their relevance to orthodontics have been a highly debated topic in recent years. CMDs relate to discomfort of the temporomandibular joint (TMJ). The disorder, characterized by different symptoms, has psychogenic influence, affecting the quality of life of individuals. To treat this muntifactorial disorder, a number of psychophysiological and psychological explanations have been advanced, none of which was able to clearly establish a direct causal link with CMD (Michelotti and Iodice [1]).

There is no agreement on the definition of CMD in the literature. Dibbets and van der Weele [2] maintain that many different definitions of CMD dysfunction have come into existence and, consequently, even in a single individual the diagnosis of TMJ dysfunction depends on the definition used. For Luther [3], CMDs refer to a variety of symptoms, signs, and combinations that are assigned to the TMJ and its related structures. For the present study, "craniomandibular disorders" are used to refer to disorders affecting either the cephalic region or the TMJ, or both (Okeson and de Leeuw, 2011 [4]). These conditions impact the quality of life of patients as well as their social functioning [5].

Traditionally, it was believed that these disorders could be treated through a gnathological occlusal approach. However, both the gnathological and the neuromuscular approaches show marked differences; this is true with patients who manifest numerous symptoms that compromise their craniomandibular function. Therefore, a new approach, "the biopsychosocial model", has been suggested; it has gained wide recognition among the dental scientific community since its explanations are heavily based on a "medico-cognitive approach".

The aim of this chapter is to bring into focus the literature on the choice of the mandibular reference position in orthodontic treatment; of a particular reference to this paper are the intercuspal position, the centric relation position, and/or the therapeutic position.

2. Craniomandibular disorders and orthodontics

The literature on craniomandibular disorders show that 75% of the population manifests at least one symptom of CMD and about 33% demonstrate at least one symptom (i.e. facial pain, joint pain, etc.) [6]. Saghafi and Curl [7] pointed out that 85 to 95% of the population would exhibit at least one or more symptoms of CMD during their life. Interestingly, about 5 to 6% of the population has been reported to have clinically significant CMD-related jaw pain [8]. CMDs affect all age groups (i.e., children, adolescents, and adults). In this respect, Egermark-Eriksson et al. [9] claimed that CMDs manifest themselves in 16–25% of children, 30% of adolescents, and 60% of adults. Other studies found these abnormalities in children of varying ages [10–13]. An increase in CMD prevalence with increasing age has been found in children [14, 15]. A difference in CMD prevalence between boys and girls during adolescence has also been reported, where CMD prevalence is higher and the severity of signs and symptoms more pronounced in girls compared with boys [15, 16]. General health problems are also more frequently reported in adolescents with CMD compared with a control group [16]. Furthermore, adolescents with recurrent headaches have more symptoms and signs of CMD compared with those without headaches [17], and children and adolescents with CMD often have other painful conditions [16]. Although previous studies found the prevalence of symptoms and signs of CMD to be similar in men and women [18], later studies have reported a higher prevalence among women [8, 19, 20].

In our context, two studies about CMD prevalence have been undertaken: The first study involved a sample of 142 participants studying at Casablanca Dental School. The study revealed that 52.8% of students have at least one sign of CMD, and pain was present in 17.5% of the sample (Bourzgui et al. [21]). The second study included all patients receiving orthodontic treatment at the Dentofacial Orthopedic Unit of Casablanca Dental School, during the different stages of treatment and over a period of 4 months. Distribution of the sample by joint noise shows that 14% of cases reported recent joint noise; 12.3% reported antecedent noise. The joint noise lasted more than a month in 92.9% of the cases and less than a month in 7.1% of the cases. The pain was periorbital in 22.1% of the cases, auricular-angular in 55.5%, perioral in 11.2%, and cervical in 11.2%. Pain was moderate in 71.54% of cases and severe in 28.4% (Bourzgui et al. [22]).

It is important to note that the etiology and pathophysiology of CMD are poorly understood; the fluctuation of symptoms with successive activation and remission periods makes their study difficult. If the multifactorial aspect of the disorder is no longer a subject of inquiry, the role of different factors in CMD is still unclear and is yet to be elucidated. Over the years, many classification schemes for CMD factors have been advanced. Among the classifications that are frequently used is de Boever et al.'s classification [23]:

http://dx.doi.org/10.5772/60061

i. Predisposing factors that increase CMD risk: Structural factors (occlusal patterns, loss of calibration, etc.), tissue quality, systemic diseases, age, facial typology, and bruxism;

ii. Trigger factors: Macrotrauma or microtrauma, bruxism, and articular tolerance ability excess;

iii. Perpetuating factors: Mostly neglected but usually dominated by behavioral, social, and emotional status, they tend to be more predominant.

According to Palla [24], the influence of behavioral factors is far more important than the severity of symptoms. In their study, Manfredini et al. [25] showed that pain-related disability is strongly associated with depression and somatization. Other neurobiological mechanisms such as interference with endogenous regulator of the pain system, genetic factors, as well as the disruption of the adrenergic function of the autonomic nervous system have also been reported as contributing factors in the pathogenesis of CMD (Monaco et al. [26]; Rinchuse and Kandasamy [27]).

In addition, the stomatognathic system is a complicated structure, and patients usually adapt to their existing vertical dimension of occlusion. When compensation capacity is limited, weak structures such as teeth, muscles, and joints yield and dysfunction results [6]. In the same way, Winocur et al. [28] conclude that hyper-functions relating to parafunctional habits (i.e., bruxism, use of chewing gum) contribute significantly to the onset of joint pain and noise. Conti et al. reached the same conclusion in 2003 when they found a positive association between parafunction and CMD [29].

Recently, a lot of studies that investigate occlusion have come into existence; this is because occlusion has for long been claimed to play a significant role in CMD. That there is a relationship between occlusion and CMD was originally based on clinical experience. However, recent scientific literature does not support this hypothesis; the claims made by Luther [2], John et al. [30], and Badel et al. [31] seem to point in this direction; in fact, they did not find any strong support for a link between occlusion and CMD, [6, 11, 32, 33].

Researchers such as Pullinger and Seligman [34] claimed that the effect of occlusion on CMD is minimal and does not exceed 10–20% in all major clinical cases. They further maintained that occlusion in CMD may be a perpetuating factor. However, Luther [2] and others (John et al. [30], Badel et al. [31]) argued that there is no causal relationship between occlusion and CMD. They further noted that because of flaws in investigatory design, the causative association between dental occlusion and TMJ has not been validated and remains an open question. Kirveskari and Alanen [32] have stated "much, if not most, of the confusion about the role of occlusion is deeply rooted in a lack of appreciation of the problems in causal inference."

In their study, McNamara et al. [35] claimed that the absence of an ideal gnathologic occlusion at the end of orthodontic treatment is not likely to lead to CMD. On the contrary, they classified five factors as statistically significant; they correlate perfectly well with their appearance: The previous skeletal open bite, the occlusal overbite exceeding 6–7mm, the unilateral cross bite, the absence of more than five later teeth, and sliding between centric position and intercuspal

position exceeding 4mm. Marzooq et al. [36] found that studies present conflicting scientific evidence in relation to the claim that malocclusions, such as overbite, passive interferences, and sliding between the occlusion of maximum intercuspidation and centric occlusion, contribute to CMD development.

Today, there is good scientific evidence that the role of the occlusion should not be overrated to avoid surdiagnostics and overtreatment (Turp and Schindler [37]). It should therefore continue to be an important component of therapy practices and may constitute one of the main factors of development of the stomatognathic system.

The possible association between orthodontic, orthopedic, or orthochirurgical treatment and CMD has frequently been a subject of debate among clinicians in the last decades (Rtun et al. [38]; Beattie et al. [39]).

Despite the great number of studies, many doubts concerning the real participation of orthodontic treatment in the etiology, prevention, and treatment of CMD still persist. Therefore, most researchers agree on the absence of a causal relationship between orthodontics and CMD (Bourzgui et al. in 2009 [21]; Luther in 1998 [40]; Henrikson et al. in 2000 [41]; Conti et al. in 2003 [29]; McNamara et al. in 1995 [35]). In fact, a number of conditions (i.e., muscle incoordination, unstable disc-condyle relationship, and bone alterations) can interfere with the occlusal relationship and with orthodontic analysis.

According to McNamara [42], CMD may develop during orthodontic treatment; there is no evidence that orthodontic mechanics can expose the subject to a higher risk for CMD, and there is little evidence that orthodontic treatment canprevent CMD. Furthermore, Conti et al. [43] showed that orthodontic treatment undertaken during adolescence can neither augment nor diminish the risk of developing CMD later. This is valid regardless of which mechanics is used: With or without extractions and with or without orthopedic appliances.

Al-Riyami et al. showed an improvement of articular noise (portray bangs rather than clicking) after orthognathic surgery. Also the limitation of oral opening and deduction seems to disappear two years after surgery [44]. This claim contradicts the findings of Borstlap et al. [45] who believe that orthognathic surgery can draw away effects which are likely to contribute to CMD development. Luther et al. could not identify any single evidence regarding the preventive role of orthodontic treatment in CMD. The authors also concluded that patients' consent should reflect the seemingly elusive character of episodic development/signs of relief [46].

3. Mandibular Reference Position in Orthodontic Treatment

Orthodontists should be able to handle such clinical situations, basing their work on scientific evidence and considering the multifactorial aspect of such trouble. They must also be able to distinguish patients with a CMD risk and patients without a CMD risk. During intervention, they must opt for criteria that favor occlusal stability while maintaining its functions [47]. In addition, orthodontic treatment is considered an occlusal therapy that should be done with mandibular reference position for occlusion reconstruction. The reference system assesses

http://dx.doi.org/10.5772/60061

changes made relative to the initial state but also to transfer information from what is clinical to what is laboratory and vice versa. But the question that one should address is: which reference to choose during orthodontic treatment especially in the presence of CMD? This issue has attracted considerable controversy.

The concept of reference implies a reproducible and recordable situation, which is not affected by the proposed treatment. Three suggestions are possible in this context (Orthlieb et al. [48]):

i. Intercuspal occlusal position (IOP);

ii. Centric relation occlusal position (COP);

iii. "Therapeutic mandibular position" is the position that you want the mandible to be treated with.

3.1. Intercuspal Occlusal Position (IOP)

This is the mandibular position that involves contact between the teeth while swallowing. In this position, there are an infinite number of condylar positions in the glenoid cavity.

3.2. Centric Relation (CR)

Centric relation is defined as the relationship of the mandible to the maxilla when the condyles are in their most posterior unstrained positions in the glenoid fossa [27, 49].

According to "Turp et al. [50], the definition of centric relation has changed over the past half-century from a retruded, posterior and, for the most part, superior condyle position to an anterior-superior condyle position.

CR is used when restoring patients with removable or fixed prostheses. When the dentist attempts to relate the patient's maxilla and mandible, but the patient does not have the teeth to establish the vertical dimension of occlusion, a different approach is required. The condyle can only be in the same position it was led to last time by the dentist if it is moved to the most superior and anterior position within the fossa.

Centric relation believers [27, 49, 50] state the relationship of the mandible to the maxilla when the properly aligned condyle-disc assemblies are in the most superior position against the eminentiae irrespective of Occlusal Vertical Dimension (OVD) or tooth position. Centric relation concepts have largely been replaced by neuromuscular dentistry concepts that are considered far more physiologic.

4. Which treatment method to choose: CP or IOP?

Turp and Schindler [37] assume that the orthodontic approach is usually associated with a complete occlusal rehabilitation. Therefore, diagnosis and treatment can only be done by centric relation (CR) in order to achieve coordination between the occlusion and the masticating function showing whether the patient is symptomatic or not [51].

According to Oltramari et al. [52], CR is the position of the jaws in which the condyles have an orthopedic stable position. Thus, for any shift of centric position (CP) intercuspal occlusal position (IOP) causing changes in inter-jaw sagittal relationship, diagnosis, and treatment should be based on the analysis in CR (case 1).

4.1. Case 1

This is the case of a young adult aged 20 with inter-incisive deviation (fig1). After the diagnosis of functional origin, manipulation of centric relation showed interarch horizontal changes (fig2). Indeed, the mandible refocuses with the appearance of a right angle and left compared to the class III Angle occlusion. In this case, it is clear that the choice of the mandibular reference will be irrevocably on the centric relation position(fig2). Orthodontic treatment stabilizes the occlusion in the corrected mandibular position(fig3).

Figure 1: Occlusion at the start of treatment. Occlusion is in ClI molar and canine on the right side and the left ClIII.

Figure 1: Occlusion at the start of treatment. Occlusion is in ClI molar and canine on the right side and the left ClIII.

Figure 2: Centric relation position: ClIII canine and molar on the right and left side.

Figure 2: Centric relation position: ClIII canine and molar on the right and left side.

The IOP will only be used if it dictates the mandibular position by a maximum of stabilizing and harmoniously spreading contacts in a position close to centric relation without transversal differential (case 2).

http://dx.doi.org/10.5772/60061

Figure 2: Centric relation position: ClIII canine and molar on the right and left side.

Figure 3: Installation of occlusion in centric relation position.

Figure 3. Installation of occlusion in centric relation position

The IOP will only be used if it dictates the mandibular position by a maximum of stabilizing and harmoniously spreading contacts in a position close to centric relation without transversal differential (case 2).

4.2. Case 2

<H2>Case 2

This is the case of a patient, aged 26, who came to the clinic for purely aesthetic reasons related to his malocclusion of CLII div 1 (fig4). Clinical examination revealed a fully functional intercuspal occlusal position used as a reference throughout treatment (fig5).

This is the case of a patient, aged 26, who came to the clinic for purely aesthetic reasons related to his malocclusion of CLII div 1 (fig4). Clinical examination revealed a fully functional intercuspal occlusal position used as a reference throughout treatment (fig5).

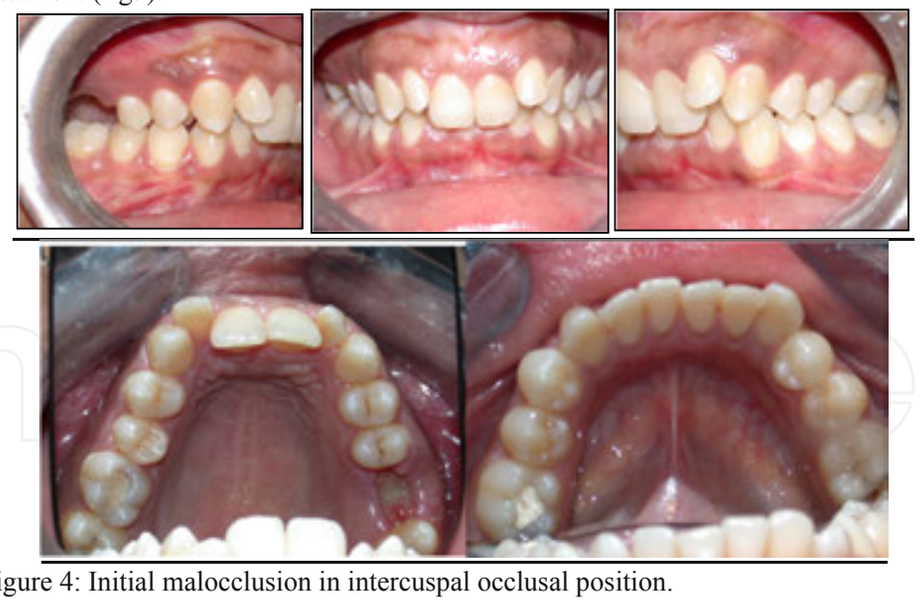
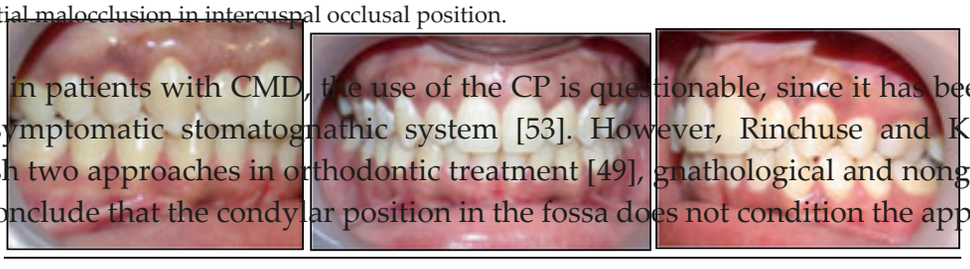


Figure 4: Initial malocclusion in intercuspal occlusal position.

Figure 4. Initial malocclusion in intercuspal occlusal position.



However, in patients with CMD, the use of the CP is questionable, since it has been defined for an asymptomatic stomatognathic system [53]. However, Rinchuse and Kandasamy distinguish two approaches in orthodontic treatment [49], gnathological and nongnathological, and conclude that the condylar position in the fossa does not condition the appearance of

Figure 5: Occlusion treatment.

Figure 5. Occlusion treatment.

However, in patients with CMD, the use of the CP is questionable, since it has been defined for an asymptomatic stomatognathic system [53]. However, Rinchuse and Kandasamy distinguish two approaches in orthodontic treatment [49], gnathological and nongnathological; and conclude that the condylar position in the fossa does not condition the appearance of CMD and articulator mounting as well as the determination to harmonize CR and IOP brings about very little or no benefit in orthodontics.

Hamata et al. [53] showed that there is no difference between the splints made in CP or IOP for patients with a good occlusal stability without large discrepancy between CP and IOP. To defend the IOP as a reference, a number of studies have shown that after a mandibular repositioning in the CP by successive adjustments of the splints, the final neuromuscular position of the mandible, which is asymptomatic, differs from the position at the beginning of treatment (CP) [53] (case 3).

According to Tripodakis et al. [54], the neuromuscular position is located between IOP and CR in the antero-posterior direction. So the IOP position can be taken as a starting point for neuromuscular equilibrium position because it is easier to perform and reduces the processing costs and the time spent in orthodontic treatment.

<H2>Case 3

This is the case of a 21-year-old patient who had a disc displacement on the left side(fig6, 7, 8).. He was referred to the clinic by his occlusodontist to sustain mandibular position after repositioning occlusal resin splints (fig9, 10).

CMD and articulator mounting as well as the determination to harmonize CR and IOP brings about very little or no benefit in orthodontics.

Hamata et al. [53] showed that there is no difference between the splints made in CP or IOP for patients with a good occlusal stability without large discrepancy between CP and IOP. To defend the IOP as a reference, a number of studies have shown that after a mandibular repositioning in the CP by successive adjustments of the splints, the final neuromuscular position of the mandible, which is asymptomatic, differs from the position at the beginning of treatment (CP) [53] (case 3).

According to Tripodakis et al. [54], the neuromuscular position is located between IOP and CR in the antero-posterior direction. So the IOP position can be taken as a starting point for neuromuscular equilibrium position because it is easier to perform and reduces the processing costs and the time spent in orthodontic treatment.

4.3. Case 3

This is the case of a 21-year-old patient who had a disc displacement on the left side(fig6, 7, 8).. He was referred to the clinic by his occlusodontist to sustain mandibular position after repositioning occlusal resin splints (fig9, 10).

Figure 6: Initial malocclusion in therapeutic position.

Figure 6. Initial malocclusion in therapeutic position.

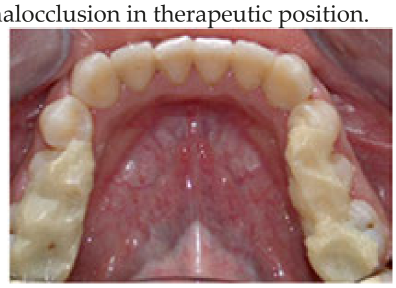


Figure7: Mandible repositioned occlusal splints.

http://dx.doi.org/10.5772/60061

Figure 6: Initial malocclusion in therapeutic position.

Figure 6: Initial malocclusion in therapeutic position.

Figure7: Mandible repositioned occlusal splints.

Figure7: Mandible repositioned occlusal splints.

Figure 7. Mandible repositioned occlusal splints.

Figure 8: Maxillary arch preparation.

Figure 8: Maxillary arch preparation.

Figure 8: Maxillary arch preparation.

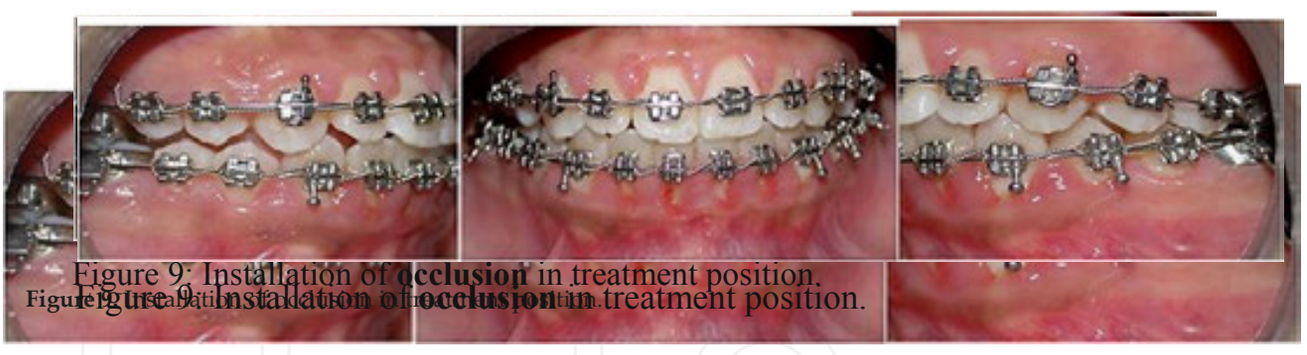


Figure 9: Installation of **occlusion** in treatment position.

Figure 9: Installation of occlusion in treatment position.

Figure 9: Installation of occlusion in treatment position.

Figure 10: Occlusion after treatment.

Figure 10: Occlusion after treatment.

Figure 10. Occlusion after treatment.

Figure 10: Occlusion after treatment.

In summary, much controversy exists in the literature regarding the most reliable reference in orthodontics, but it is important to retain the simplified approach of Orthlieb et al. [48]. If an IOP is not affected by the treatment undertaken as a result of a mandibular repositioning which

is itself resulting from a disk displacement redaction (DDR), it should be used. Any disruption of the IOP by a centering or sitting defect must choose the CR as a reference. In this case, it must be functional, that is, either natural or stabilized.

5. Conclusion

At the current state of research, CMDs do not seem to be directly related to orthodontic treatment, and their appearance cannot be predicted or prevented by any means. Therefore, one needs to be vigilant in examining and approaching each patient before, during, and after orthodontic treatment, especially when risk factors dominate the clinical picture. So when the orthodontist is faced with the presence of signs, symptoms, or problems related to internal articulatory disturbances, he/she should treat these disturbances before continuing treatment, especially that they can cause morphological disorders in young patients. In this case, the noninvasive reversible means remains the most appropriate method to use. In his/her treatment, the orthodontist must adopt a mandibular reference adapted to his/her patient which best respects the balance existing in the stomatognathic system.

Author details

Farid Bourzgui[1*], Hakima Aghoutan[1] and Samir Diouny[2]

*Address all correspondence to: faridbourzgui@gmail.com

1 Department of Dento-facial Orthopedic, Faculty of Dental Medicine, Casablanca Hassan II University, Morocco

2 Department of English, Faculty of Letters & Human Sciences, Chouaib Doukkali University, El Jadida, Morocco

References

[1] A. Michelotti and G. Iodice, "The role of orthodontics in temporomandibular disorders," *Journal of Oral Rehabilitation*, vol. 37, no. 6, pp. 411–429, 2010.

[2] J. M. H. Dibbets and L. T. van der Weele, "Orthodontic treatment in relation to symptoms attributed to dysfunction of the temporomandibular joint A 10-year report of the University of Groningen study," *American Journal of Orthodontics and Dentofacial Orthopedics*, vol. 91, no. 3, pp. 193–199, 1987.

[3] F. Luther, "Orthodontics and the temporomandibular joint: where are we now? Part 2. Functional occlusion, malocclusion, and TMD," *Angle Orthodontist*, vol. 68, no. 4, pp. 305–318, 1998.

[4] J. P. Okeson and R. de Leeuw, "Differential diagnosis of temporomandibular disorders and other orofacial pain disorders," *Dental Clinics of North America*, vol. 55, no. 1, pp. 105–120, 2011.

[5] G. E. Tjakkes, J. Reinders, E. M. Tenvergert, and B. Stegenga, "TMD pain: the effect on health related quality of life and the influence of pain duration," *Health and Quality of Life Outcomes*, vol. 8, article 46, 2010.

[6] F. Bourzgui, Ed.,*Orthodontics—BasicAspectsandClinicalConsiderations* (Part 4. Temporomandibular Disorder and Orthodontic: 327–76), InTech, Rijeka, Croatia, 2012.

[7] D. Saghafi and D. D. Curl, "Chiropractic manipulation of anteriorly displaced temporomandibular disc with adhesion," *Journal of Manipulative and Physiological Therapeutics*, vol. 18, no. 2, pp. 98–104, 1995.

[8] J. P. Goulet, G. J. Lavigne, and J. P. Lund, "Jaw pain prevalence among French-speaking Canadians in Que ̈bec and related symptoms of temporomandibular disorders," *Journal of Dental Research*, vol. 74, no. 11, pp. 1738–1744, 1995.

[9] I. Egermark-Eriksson, G. E. Carlsson, T. Magnusson, and B. Thilander, "A longitudinal study on malocclusion in relation to signs and symptoms of cranio-mandibular disorders in children and adolescents," *European Journal of Orthodontics*, vol. 12, no. 4, pp. 399–407, 1990.

[10] B. Thilander, G. Rubio, L. Pena, and C. de Mayorga, "Prevalence of temporomandibular dysfunction and its association with malocclusion in children and adolescents: an epidemiologic study related to specified stages of dental development," *Angle Orthodontist*, vol. 72, no. 2, pp. 146–154, 2002.

[11] I. Egermark, T. Magnusson, and G. E. Carlsson, "A 20-year follow-up of signs and symptoms of temporomandibular disorders and malocclusions in subjects with and without orthodontic treatment in childhood," *Angle Orthodontist*, vol. 73, no. 2, pp. 109–115, 2003.

[12] N. Alamoudi, N. Farsi, N. O. Salako, and R. Feteih, "Temporo- mandibular disorders among school children," *Journal of Clinical Pediatric Dentistry*, vol. 22, no. 4, pp. 323–328, 1998.

[13] S. D. Keeling, S. McGorray, T. T. Wheeler, and G. J. King, "Risk factors associated with temporomandibular joint sounds in children 6 to 12 years of age," *American Journal of Orthodontics and Dentofacial Orthopedics*, vol. 105, no. 3, pp. 279–287, 1994.

[14] T. Magnusson, I. Egermark-Eriksson, and G. E. Carlsson, "Four-year longitudinal study of mandibular dysfunction in children," *Community Dentistry and Oral Epidemiology*, vol. 13, no. 2, pp. 117–120, 1985.

[15] I. Nilsson, "Reliability, validity, incidence and impact of temporormandibular pain disorders in adolescents," *Swedish Dental Journal. Supplement*, vol. 183, pp. 7–86, 2007.

[16] K. Wahlund, "Temporomandibular disorders in adolescents. Epidemiological and methodological studies and a randomized controlled trial," *Swedish Dental Journal. Supplement*, vol. 164, pp. 2–64, 2003.

[17] A. Wa nman and G. Agerberg, "Recurrent headaches and craniomandibular disorders in adolescents: a longitudinal study," *Journal of Craniomandibular Disorders*, vol. 1, no. 4, pp. 229– 236, 1987.

[18] M. Helkimo, "Epidemiological surveys of dysfunction of the masticatory system," *Oral Science Reviews*, vol. 7, pp. 54–69, 1976.

[19] S. F. Dworkin, K. H. Huggins, L. LeResche et al., "Epidemiology of signs and symptoms in temporomandibular disorders: clinical signs in cases and controls," *The Journal of the American Dental Association*, vol. 120, no. 3, pp. 273–281, 1990.

[20] T. Magnusson, I. Egermark, and G. E. Carlsson, "A longitudinal epidemiologic study of signs and symptoms of temporomandibular disorders from 15 to 35 years of age," *Journal of Orofacial Pain*, vol. 14, no. 4, pp. 310–319, 2000.

[21] F. Bourzgui, M. Sebbar, S. FassiFehri, and A. El Hamid, "Craniomandibular dysfunction and malocclusions," *International Orthodontics*, vol. 7, no. 2, pp. 170–180, 2009.

[22] F. Bourzgui, M. Sebbar, A. Nadour, and M. Hamza, "Prevalence of temporomandibular dysfunction in orthodontic treatment," *International Orthodontics*, vol. 8, no. 4, pp. 386–398, 2010.

[23] J. A. de Boever, G. E. Carlsson, and I. J. Klineberg, "Need for occlusal therapy and prosthodontic treatment in the management of temporomandibular disorders. Part I. Occlusal interferences and occlusal adjustment," *Journal of Oral Rehabilitation*, vol. 27, no. 5, pp. 367–379, 2000.

[24] S. Palla, "Long terme effects of temporomandibular disorders treatment," *Real Clinica*, vol. 7, no. 2, pp. 229–238, 1996.

[25] D. Manfredini, E. Winocur, J. Ahlberg, L. Guarda-Nardini, and F. Lobbezoo, "Psychosocial impairment in temporomandibular disorders patients. RDC/TMD axis II findings from a multicentre study," *Journal of Dentistry*, vol. 38, no. 10, pp. 765–772, 2010.

[26] A. Monaco, R. Cattaneo, L. Mesin, I. Ciarrocchi, F. Sgolastra, and D. Pietropaoli, "Dysregulation of the autonomous nervous system in patients with temporomandibular disorder: a pupillometric study," *PLoS ONE*, vol. 7, no. 9, Article ID e45424, 2012.

[27] D. J. Rinchuse and S. Kandasamy, "Orthodontics and TMD," in *Evidence-Based Clinical Orthodontics*, P. G. Miles, D. J. Rinchuse, and D. J. Rinchuse, Eds., pp. 157–166, Quintessence, Hong Kong, China, 2012.

[28] E. Winocur, A. Gavish, T. Finkelshtein, M. Halachmi, and E. Gazit, "Oral habits among adolescent girls and their association with symptoms of temporomandibular disorders," *Journal of Oral Rehabilitation*, vol. 28, no. 7, pp. 624–629, 2001.

[29] A. Conti, M. Freitas, P. Conti, J. Henriques, and G. Janson, "Relationship between signs and symptoms of temporomandibular disorders and orthodontic treatment: a crosssectional study," *Angle Orthodontist*, vol. 73, no. 4, pp. 411–417, 2003.

[30] M. T. John, C. Hirsch, M. T. Drangsholt, L. A. Mancl, and J. M. Setz, "Overbite and overjet are not related to self-report of temporomandibular disorder symptoms," *Journal of Dental Research*, vol. 81, no. 3, pp. 164–169, 2002.

[31] T. Badel, M. Marotti, I. S. Pavicin, and V. Basic´-Kes, "Temporomandibular disorders and occlusion," *ActaClinicaCroatica*, vol. 51, no. 3, pp. 419–424, 2012.

[32] P. Kirveskari and P. Alanen, "Paradigms and EBD," *Journal of Orofacial Pain*, vol. 23, no. 4, pp. 299–300, 2009.

[33] A. Michelotti, M. Farella, L. M. Gallo, A. Veltri, S. Palla, and R. Martina, "Effect of occlusal interference on habitual activity of human masseter," *Journal of Dental Research*, vol. 84, no. 7, pp. 644–648, 2005.

[34] A. G. Pullinger and D. A. Seligman, "Quantification and validation of predictive values of occlusal variables in temporomandibular disorders using a multifactorial analysis," *Journal of Prosthetic Dentistry*, vol. 83, no. 1, pp. 66–75, 2000.

[35] J. A. McNamara Jr., D. A. Seligman, and J. P. Okeson, "Occlusion, orthodontic treatment, and temporomandibulardisorders: a review," *Journal of Orofacial Pain*, vol. 9, no. 1, pp. 73–90, 1995.

[36] A. A. Marzooq, M. Yatabe, and M. Ai, "What types of occlusal factors play a role in temporomandibular disorders...?—a literature review," *Journal of Medical and Dental Sciences*, vol. 46, no. 3, pp. 111–116, 1999.

[37] J. C. Tu rp and H. Schindler, "The dental occlusion as a suspected cause for TMDs: epidemiological and etiological considerations," *Journal of Oral Rehabilitation*, vol. 39, pp. 502– 512, 2012.

[38] J. Rtun, L. G. Hollender, and E. L. Truelove, "Relationship between orthodontic treatment, condylar position, and internal derangement in the temporomandibular joint," *American Journal of Orthodontics and Dentofacial Orthopedics*, vol. 101, no. 1, pp. 48–53, 1992.

[39] J. R. Beattie, D. E. Paquette, and L. E. Johnston, "The functional impact of extraction and nonextraction treatments: a long-term comparison in patients with 'borderline',

equally susceptible class II malocclusions," *American Journal of Orthodontics and Dentofacial Orthopedics*, vol. 105, no. 5, pp. 444–449, 1994.

[40] F. Luther, "Orthodontics and the temporomandibular joint: Where are we now? Part 1. Orthodontic treatment and temporomandibular disorders," *Angle Orthodontist*, vol. 68, no. 4, pp. 295–304, 1998.

[41] T. Henrikson, M. Nilner, and J. Kurol, "Signs of temporomandibular disorders in girls receiving orthodontic treatment. A prospective and longitudinal comparison with untreated Class II malocclusions and normal occlusion subjects," *European Journal of Orthodontics*, vol. 22, no. 3, pp. 271–281, 2000.

[42] J. A. McNamara Jr., "Orthodontic treatment and temporomandibular disorders," *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics*, vol. 83, no. 1, pp. 107–117, 1997.

[43] A. C. D. C. F. Conti, P. V. P. Oltramari, R. D. L. Navarro, and M. R. de Almeida, "Examination of temporomandibular disorders in the orthodontic patient: a clinical guide," *Journal of Applied Oral Science*, vol. 15, no. 1, pp. 77–82, 2007.

[44] S. Al-Riyami, S. J. Cunningham, and D. R. Moles, "Orthognathic treatment and temporomandibular disorders: a systematic review. Part 2. Signs and symptoms and meta-analyses," *American Journal of Orthodontics and Dentofacial Orthopedics*, vol. 136, no. 5, pp. 626.e1–626.e16, 2009.

[45] W. A. Borstlap, P. J. W. Stoelinga, T. J. M. Hoppenreijs, and M. A. van't Hof, "Stabilisation of sagittal split advancement osteotomies with miniplates: a prospective, multicentre study with two-year follow-up. Part III—condylar remodelling and resorption," *International Journal of Oral and Maxillofacial Surgery*, vol. 33, no. 7, pp. 649–655, 2004.

[46] F. Luther, S. Layton, and F. McDonald, "Orthodontics for treating temporomandibular joint (TMJ) disorders," *Cochrane Database of Systematic Reviews*, no. 7, Article ID CD006541, 2010.

[47] A. Decker and J. C. Kohault, "Traitements des dysfonctions temporomandibulaires," in *Orthodontie de l'adulte*, P. Canal and A. Salvadori, Eds., pp. 231–238, Masson, Paris, France, 2008.

[48] J. D. Orthlieb, D. Brocard, J. Schittly, and A. Manie`re-Ezvan, *OcclusodontiePratique*, Collection JPIO, CDP, 2006.

[49] D. J. Rinchuse and S. Kandasamy, "Centric relation: a historical and contemporary orthodontic perspective," *Journal of the American Dental Association*, vol. 137, no. 4, pp. 494–500, 2006.

[50] J. C. Tu rp, C. S. Greene, and J. R. Strub, "Dental occlusion: a critical reflection on past, present and future concepts," *Journal of Oral Rehabilitation*, vol. 35, no. 6, pp. 446–453, 2008.

[51] F. E. Cordray, "Centric relation treatment and articulator mountings in orthodontics," *The Angle Orthodontist*, vol. 66, no. 2, pp. 153–158, 1996.

[52] P. V. P. Oltramari, A. C. C. F. Conti, R. D. L. Navarro, M. R. de Almeida, R. R. de Almeida-Pedrin, and F. P. C. Ferreira, "Importance of occlusion aspects in the completion of orthodontic treatment," *Brazilian Dental Journal*, vol. 18, no. 1, pp. 78–82, 2007.

[53] M. M. Hamata, P. R. J. Zuim, and A. R. Garcia, "Comparative evaluation of the efficacy of occlusal splints fabricated in centric relation or maximum intercuspation in temporomandibular disorders patients," *Journal of Applied Oral Science*, vol. 17, no. 1, pp. 32–38, 2009.

[54] A. P. Tripodakis, J. B. Smulow, N. R. Mehta, and R. E. Clark, "Clinical study of location and reproducibility of three mandibular positions in relation to body posture and muscle function," The Journal of Prosthetic Dentistry, vol. 73, no. 2, pp. 190– 198, 1995.

IntechOpen